Space Weather Technical Forecast

Issued on Thursday, 15 December 2022 at 01:14 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further M-flares (R1-R2 Blackouts) likely from AR3165

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity is Moderate with 8 M-flares (7 R1 and 1 R2) observed in the last 24 hours, from AR3165 (Dac/Beta-Gamma-Delta) with peak flare M6.4 at 14/1442 UTC. These flares followed the occurrence of flux emergence amongst its trailer and intermediate regions with mixed polarity, resulting in an unstable magnetic configuration. A further 2 M1 flares were also observed from AR3153 (Fho/Beta) as it rotated off the Earth-facing disc, and over the southwest limb. There are a total of nine sunspots on the visible disc, with other notable but inactive regions. AR3163 Ehi-Beta Gamma, is a moderately sized spot in the southeast with ongoing slow growth amongst its trailer, also with some slight be developing magnetic complexity. AR3166 Cro/Beta in the south centre disc, and AR3168 Cso/Beta near the southeast limb have also exhibited some very slow growth. The other regions are smaller and simpler. No Earth-directed CMEs have been observed. A filament lift off near the southeast of the disc at 14/0300 UTC has been analysed as likely passing south of the Earth, but with a very slight chance of glancing interaction on the 18th.

Solar Wind / Geomagnetic Activity: Solar wind speeds, as observed at L1 by DSCOVR and ACE have been at background around 330 to 380 km/s. Density was mostly below average. The total IMF, Bt, was weak, below 8nT, but did have a gradual strengthening trend. The north-south component of the IMF, Bz, was initially weakly positive (northward) with peak value 4 nT, but then rotated to a mainly negative (southward) direction after 14/1200 UTC to around -2 to -6nT from 14/1600 UTC. Phi angle was negative (towards the Sun) throughout. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, has been at Background to Moderate levels, with peak 401 pfu at 14/1250 UTC. The associated 24-hour fluence remained steady, and well below Active (1e8 integrated pfu). Observed fluence at 15/0000 UTC was 1.12e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Moderate, especially day 1 (15th), with further M-flares from AR3165, and a slight chance of rising to High with the maximum peak flare potentially reaching X-class.

Solar Wind / Geomagnetic Activity: There are currently no Earth-directed CMEs, although there is a slight chance of a glancing interaction on day 4 (18th) due to the filament eruption CME on the 14th, although this is expected to miss passing to the south. Solar winds are expected to persist at Background to Slightly Elevated speeds until at least day 4 (18th), when the arrival of fast winds from CH54 could occur. Although the strength and timing of any enhancement is low confidence. Mainly Quiet geomagnetic activity is expected, but with a chance of increasing to Unsettled to Active intervals, with a slight chance of G1 Minor Storms day 4 (18th).

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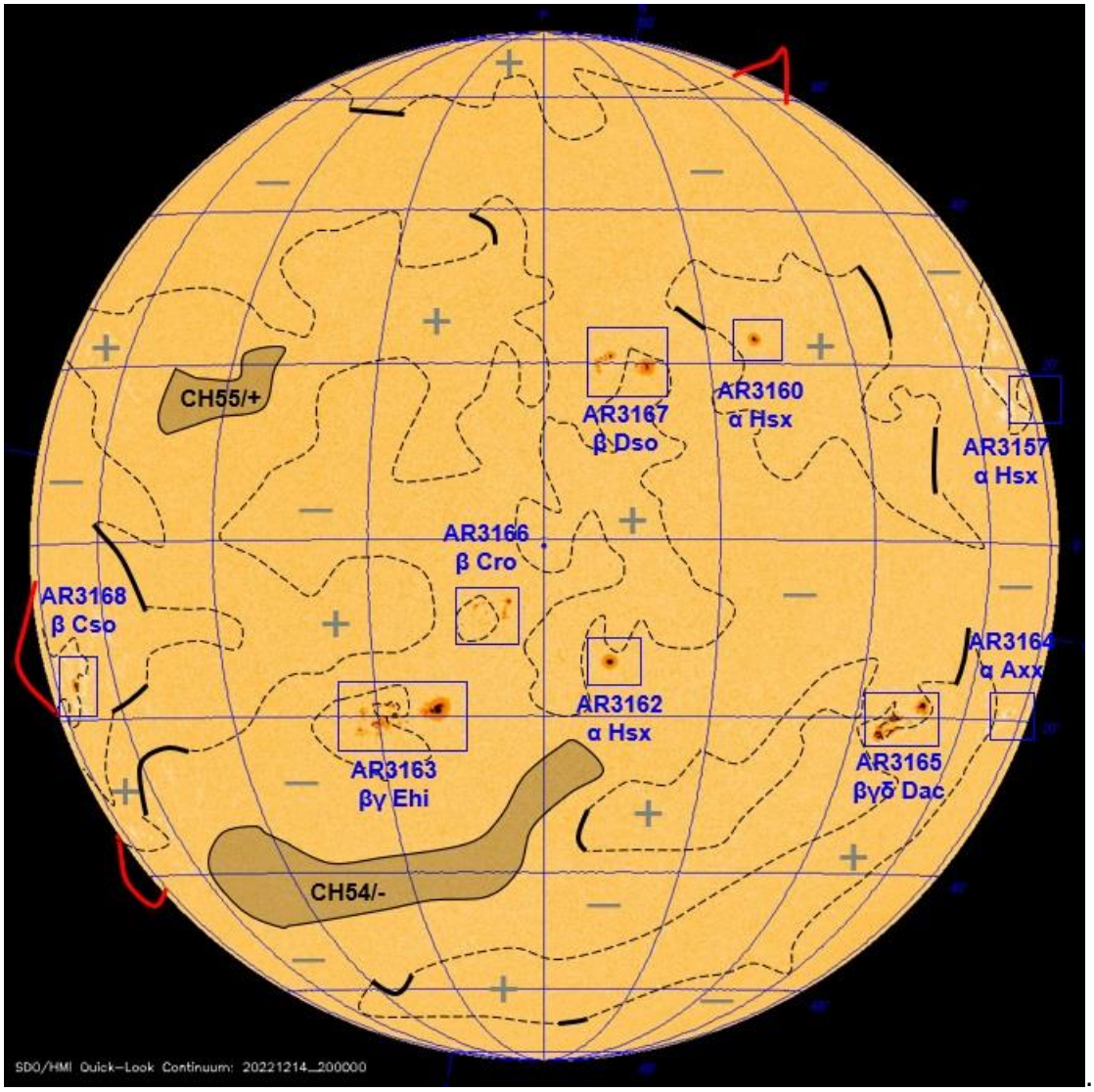
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels throughout, although there is chance of rising towards the S1 level with the occurrence of any notable flares. High energy (greater than 2 MeV) electron flux is currently at background to moderate flux levels and expected to persist at these levels. The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold.

Figure 1. Solar Analysis Valid 14/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are currently no Earth-directed CMEs. Filament lift off from the southwest, commencing around 14/0300 UTC has been assessed as missing to the south, but may bring a very slight chance of glancing impacts day 4 (18th).

Solar winds are expected to be at background to slightly elevated for much of the period, with the next likely notable fast wind arrival being that from CH54/- currently in the southwest disc. This is a persistent feature, but reduced in size and northward extent compared to the previous rotation, as sunspot development occurred to its north. However, its leading (western) edge is in a similar location, suggesting the timing of any enhancement that occurs to likely follow 27-day persistence. This arrival is not visible in current MOSWOC enlil however, giving low confidence for a significant enhancement or any subsequent geomagnetic activity.

Mainly Quiet geomagnetic activity is expected, but with a chance of increasing to Unsettled to Active intervals, with a slight chance of G1 Minor Storms day 4 (18th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2a: Solar Wind Persistence Model, showing expected weak enhancement on the 18th

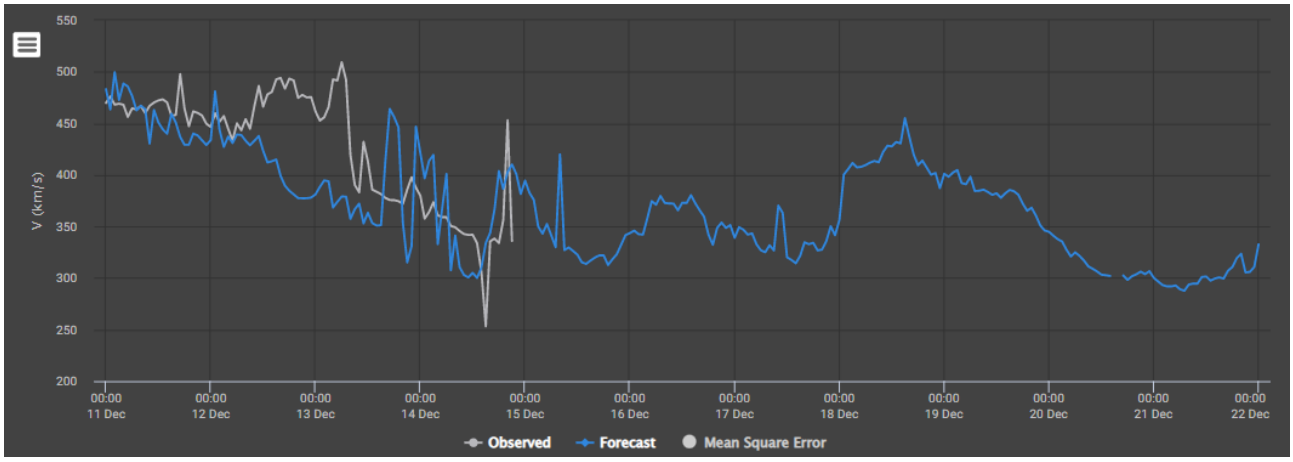

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Figure 2b: SDO aia-211 of previous rotation (left) and current (right). Can clearly see change in CH structure, although leading edge is in a similar location.

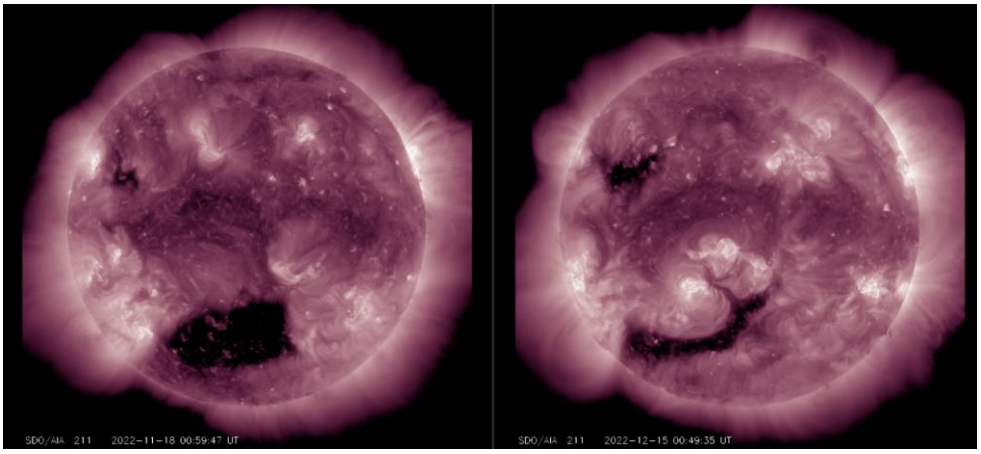
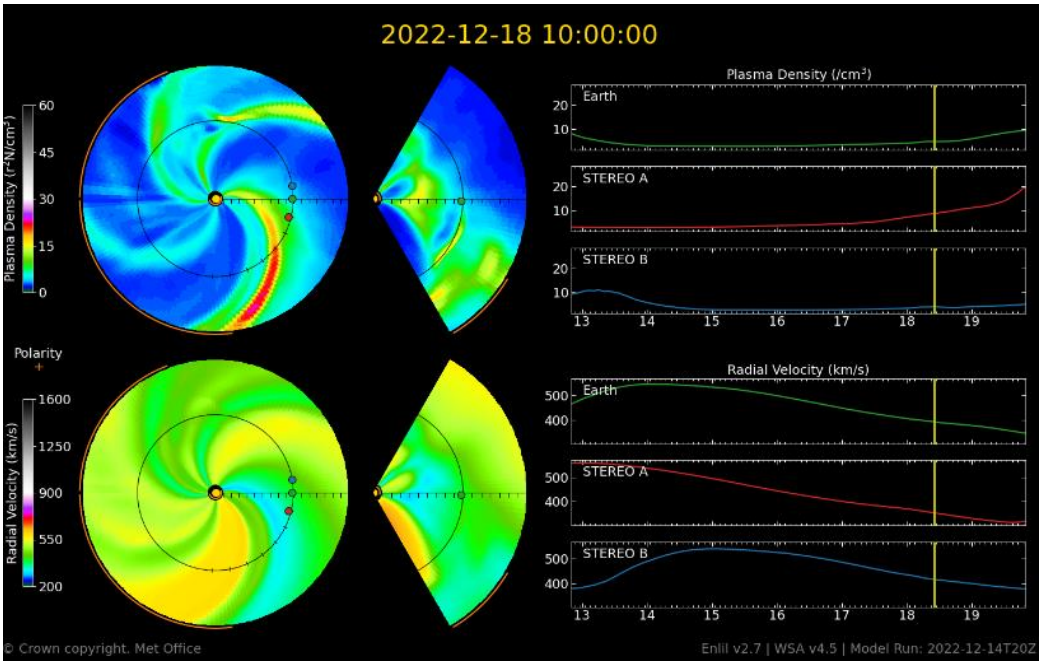
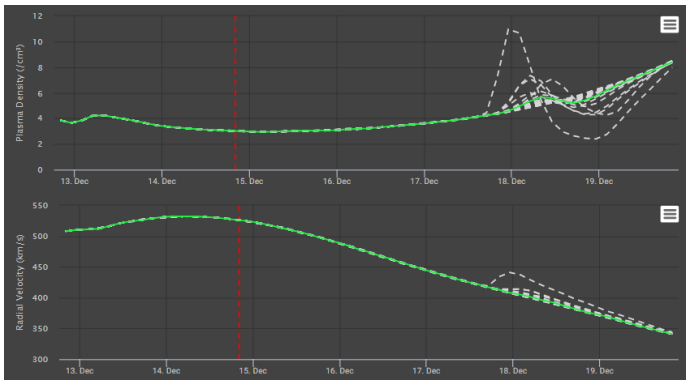


Figure 2c: Enlil showing CME from 14th missing to the south, but some glancing interaction in ensemble data. No significant enhancement visible from CH54.





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Radio Blackouts - X-Ray Flares:

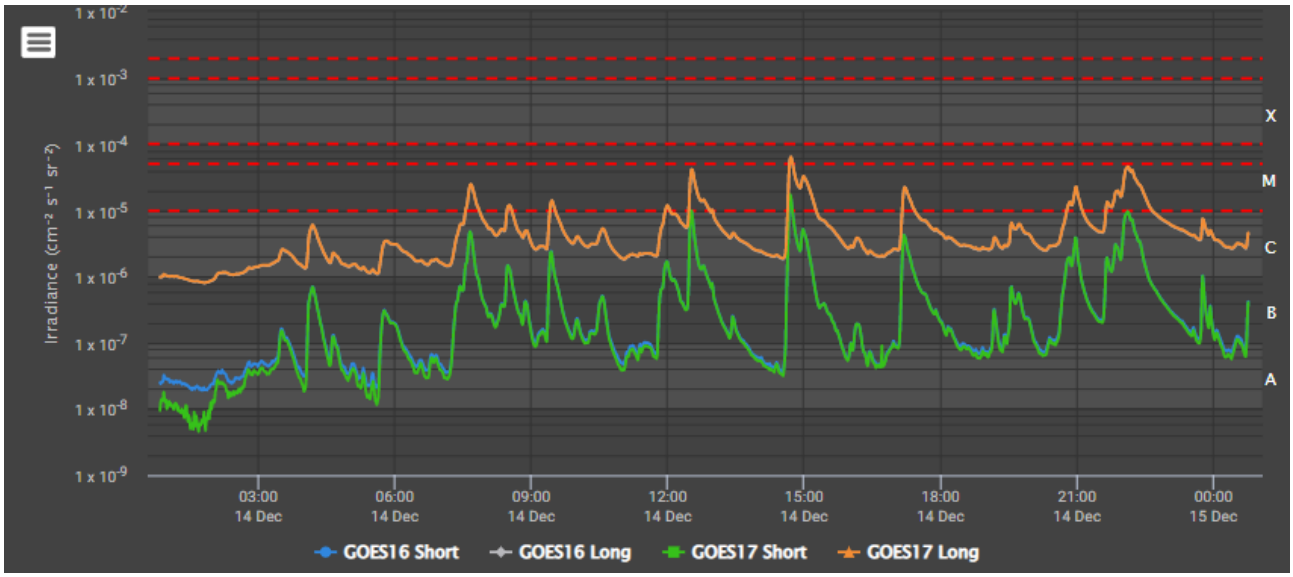
Solar activity is forecast to be Moderate with further M-flares likely, and a slight chance of becoming high with the potential maximum flare reaching X-class.

There are nine sunspot regions, with frequent M-flaring having been observed from AR3165 Dac/Beta-Gamma-Delta in the southwest. This peaked at M6.4 at 14/1442 UTC. This is a relatively small but unstable region with flux emergence occurring during the last 24 hours between its leader and trailer, resulting in the rapid growth of its penumbra area and a twisted magnetic structure.

AR3163 Ehi/Beta-gamma in the southeast is also of note, as while currently stable, continues to show slow growth amongst its intermediate spots, with some magnetic complexity developing due to these being of mixed polarity. Some growth has also been observed in both AR3166 Cro/Beta in the south-centre and AR3168 Cso/Beta near the southeast limb, with the ongoing slow development of small spots. All other regions on the disc are smaller and stable, however AR3153, which has now rotated off the southwest limb was the source of a couple of M1 flares on the 14th, and significant flares from this region still have the potential to be observed on day 1 (15th).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	50	40	40
Very Active	R3 to R5 X Class	No	15	10	5	5

Figure 3: All M-flares, except the two either side of 14/0900 UTC, due to AR3165



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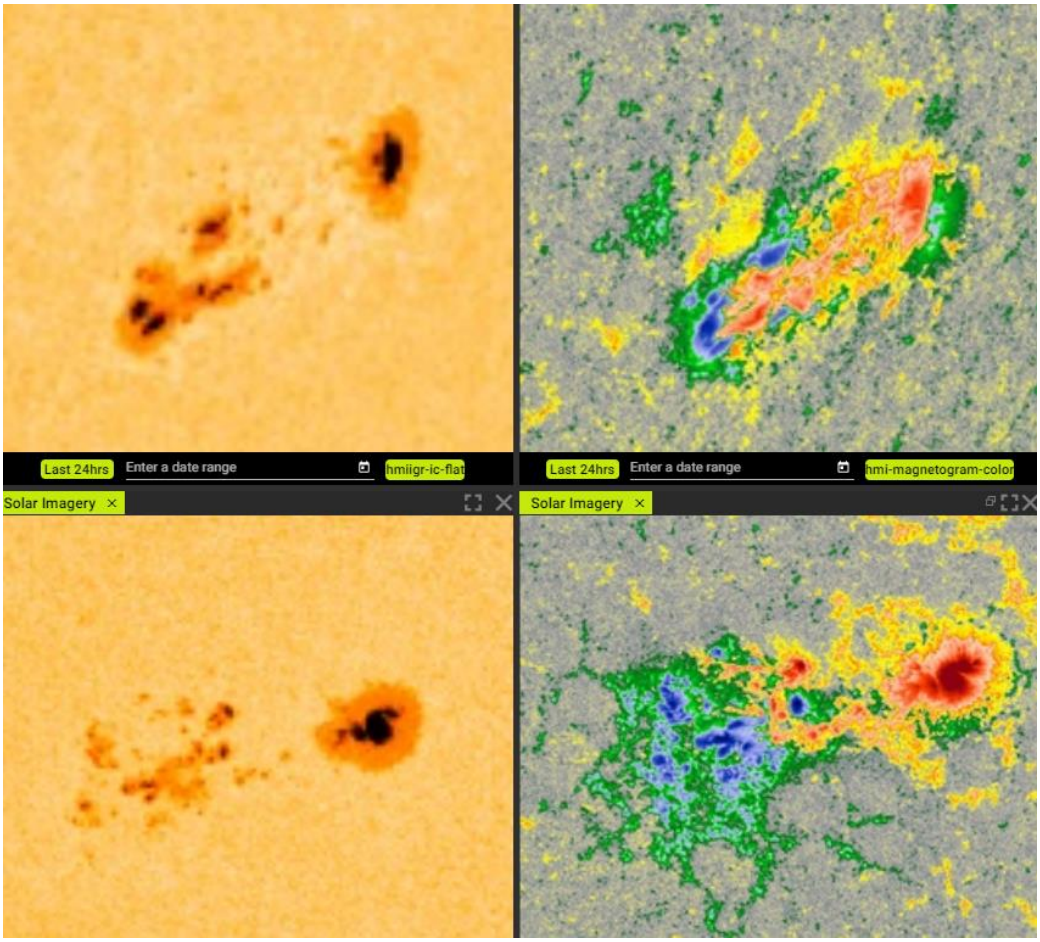
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as measured by GOES-16 is expected to remain at background levels throughout. However the frequent M-flaring of AR3165 in the southwest, along with the number of other sunspots on the disc, brings a slight chance of flux levels rising, and potentially exceeding the S1 Minor Radiation Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	10	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO HMI-Intensitygram (left) and Magnetogram (right) of AR3165 (top) and AR3163 (bottom)



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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux, as observed by GOES-16, is currently varying between Background and Moderate levels. With no significant solar wind enhancements expected, these electron flux levels are expected to persist through the period.

The associated 24 hour fluence is forecast to persist below the active threshold (1e8 integrated pfu). This is supported by REFM which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron flux and Fluence with REFM

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